

THE NORMAL OESTROUS CYCLE IN THE SOW

by

FREDERICK FRANCIS McKENZIE, B.S.A., A.M.

SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE

OF DOCTOR OF PHILOSOPHY

in the

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ACKNOWLEDGMENT

The author desires to acknowledge his appreciation of the cooperation received from Doctor Leon J. Cole and Professor E. W. Sheets, Animal Husbandry Division, United States Bureau of Animal Industry, from Dean F. B. Mumford, from the Departments of Zoology, Veterinary Science, and Animal Husbandry, of the University of Missouri. Special thanks are due Doctor Edgar Allen and Doctor Albert G. Hogan for the interest shown and the invaluable assistance given.

NOTE.—This bulletin contains the dissertation of Fred F. McKenzie, presented to the Graduate School of the University of Missouri in partial fulfillment of the conditions for the degree of Doctor of Philosophy, June, 1925. To this have been added the data on one sow, viz., 31Ad, and data on the uteri of all the animals.

The Normal Oestrous Cycle in the Sow

FRED F. MCKENZIE

Animal Husbandry Department, Missouri Agricultural Experiment Station, and
Animal Husbandry Division, Bureau of Animal Industry, United
States Department of Agriculture, Co-operating.

ABSTRACT.—Twelve sows of good breeding and individuality were kept under observation and killed at various stages of the oestrous cycle. Vaginal smears were made from the live animals. Leucocytes and epithelial cells were found in the smear in greatest numbers the week following heat and were fewest just before heat; a few cornified cells occurred at every stage, however the epithelial cells of late oestrus showed definite signs of cornification. Other external signs are described. The histology of the vestibule, vagina, and uterus with reference to oestrus is discussed in some detail. The epithelia of vestibule and vagina were thick, consisting of many cell layers, throughout oestrus proper as compared with the low epithelia of few cell layers during the dioestrus. The columnar epithelium of the uterus is highest in metoestrus, and there is a marked edema of the uterine stroma in prooestrus. The follicles and corpora lutea of the ovaries were measured and some descriptive notes made. Many follicles of small size in dioestrus were succeeded by a few follicles of medium to large size in prooestrus and early oestrus. The corpora lutea were largest between the eighth and tenth days after heat when they turned from red to pink and later became white and persisted till the middle of the second dioestrous interval. Photographs and charts illustrate the main points.

In recent years a great deal of attention has been paid to the reproductive processes in the mammalia and in particular to the phenomena connected with the oestrous cycle. Among the most outstanding contributions might be mentioned the comprehensive work of Long and Evans¹ * on the rat, Allen² on the mouse and rat, Stockard and Papanicolaou,³ Loeb,⁴ and Courrier⁵ on the guinea pig, Hartman⁶ on the opossum, Robinson⁷ on the ferret, and Marshall⁸ on the dog.

A few investigators who have used farm animals in their researches have worked out in detail the changes occurring in the genital tract in the non-pregnant female. Noted among these are Corner⁹ (sow), Marshall⁸ (sheep), Murphy^{10, 11} (ox) and his col-

*Superscript numerals refer to Bibliography on Page 29.

NOTE.—The author's preliminary account of the vaginal smear appeared in the *Anatomical Record*, Vol. 27, 1924, along with the report of another investigator. These two accounts seem to be the first that have reference to such work in swine.

laboratorst. Their efforts, however, have been directed for the most part to reporting the cyclic changes in the ovaries or the ovaries and uterus, the material sometimes coming from animals already at the market, and concerning whose history the investigator knew very little.

This paper is an attempt to report some of the initial results of an investigation planned to study the effects of certain specific nutrients upon fertility in swine. As a preliminary it was thought desirable and necessary to establish what the normal course of events is in the non-pregnant, sexually mature sow, throughout the whole genital tract. It is with this latter task that this paper deals in part. The writer ventures to hope that the partial account of the reproductive cycle here submitted may prove helpful to other investigators who have used, and will continue to use, slaughterhouse material, as it is believed that such may be fairly accurately placed in the oestrous cycle with the aid of certain criteria herein presented.

MATERIAL

The data presented here have been gathered from twelve sows. Table 1 shows briefly the breeding of these individuals and the rations fed.

TABLE 1.—BREEDING OF SOWS, AND RATIONS USED

Sow	Breed	Sire	Dam	Ration*
3P	Poland-China	W. W. G.	C. D.	J
4P	Poland-China	W. W. G.	C. D.	J
11P	Poland-China	W. W. G.	C. A. ³	J
50	Poland-China	D. K.	C. P.	K
31Ad	Poland-China	D. K.	C. G. C.	K
10	Poland-China	C.'s P	C. D.	K
7Rs	Duroc-Jersey	P. I.	W. S. R.	J
4R	Duroc-Jersey	C. O. P.	F. 130	J
5R	Duroc-Jersey	C. O. P.	3F.91	J
8R	Duroc-Jersey	C. O. P.	3F.91	J
9R	Duroc-Jersey	C. O. P.	3F.91	J
11R	Duroc-Jersey	C. O. P.	3F.91	J

*Rations.—J consists of corn 50, shorts 20, bran 25, chopped alfalfa hay 20 parts by weight; and K consists of cracked corn 70, alfalfa meal 15, tankage 15, mineral (equal parts bone ash, ground limestone and common salt) 4 parts by weight.

Of these animals 5R, 8R and 31Ad produced one litter each and 10 was bred four days before being killed. No others were bred.

†Seaborn's work on the horse appeared before this paper goes to press.¹⁸

From time to time other material has been inspected and conditions noted which have served to corroborate the observations recorded in this paper.

All animals were of good type, came from reputable herds, and were kept under careful observation.

METHODS

The animals were kept under observation particularly as to the recurrence of oestrus. The vaginal smear technique introduced by Stockard and Papanicolaou in their studies on the guinea pig has been used.

To obtain a sample of the vaginal contents the sow was run into a corner constructed simply of a gate, hung close to the floor, and swung out to a convenient angle. A handful of feed was thrown on the floor and the sow, when released from an adjoining pen, walked readily into this chute, began to eat and offered very little or no resistance throughout the examination following.

The external genitals were washed with a brush in about one per cent warm solution of Kreso Dip No. 1. A veterinarian's ear speculum, sterilized in this solution, was introduced into the vestibule. With the aid of an electric droplight suitably placed the investigator could see quite easily the condition of the vestibule. One end of a clean glass rod was rubbed gently over the antero-lateral surface of the opened vestibule, and carefully withdrawn to avoid loss of the adhering material.

To secure a smear of the vagina proper an open glass tube with a glass rod within it, somewhat on the principle of a trocar and cannula, was used. With this device it was possible to secure a sample of the contents from the vagina proper, anterior to the vulvo-vaginal sphincter muscle.

Smears were made in triplicate of the material adhering to the glass rods by the usual bacteriological technique, distilled water being used. One slide was always stained with hematoxylin and aqueous eosin, the others being filed.

Notes were taken as to the condition of the external labia before they were washed, the rigidity or relaxation of the vestibular muscles as judged by the ease with which the speculum was introduced and opened, the amount and nature of the secretion, whether the walls were comparatively dry, moist or watery, the color as indicative of the degree of vascularity or congestion, the ease with which the vulvo-vaginal sphincter could be dilated, the behavior of the animal whether excited, showing mating desire or restless-

ness, the weather, and any irregularities that might affect the individual animals or the securing of the smears.

The sows were killed at stated intervals following heat. Thus a series of genitalia have been collected which has afforded material for the study of the different stages of the oestrous cycle.

The sows were killed by stunning (except 11R which was shot), bled, and opened on the median ventral line. One ovary would then be removed, and observations made before fixing it in Bouin's picroformol. Then the remainder of the genital tract was removed, weighed and sections cut for histological study from the mid-points of the various parts as indicated in Plate I. The time from the stunning of the animal to that when the last of the tissues taken in the slaughterhouse were dropped in the killing fluid varied from 40 to 63 minutes. The organs were then photographed (less than three hours after death), measured, and frequently still other sections were cut at this time. At least one ovary from each animal was photographed, either in the fresh state or after fixation.

With 3P, 4P, 11P and 11R the ovaries and sections taken at the time of killing were removed before the animal was bled.

In every case the commercial value of the carcass was of secondary consideration. The writer killed all the animals, secured all tissues, and made all the measurements recorded.

Bouin's picroformol and saturated corrosive sublimate were used as routine fixatives. At times other killing fluids were employed as 1% osmic acid, Flemming, Zenker, Carnoy, and Orth. The usual laboratory method of dehydrating, paraffin embedding, and sectioning (4 to 10 micra) was found satisfactory. Delafield's hematoxylin and eosin were the stains used for the routine examination though additional sections were stained with microcarmine, Bismarck brown, iron hematoxylin and silver nitrate.

Smears were taken on alternate days in the afternoon just before the evening feed was given. In addition to the regular smearing on two occasions the animals were smeared at closer intervals over a short period. Smears were always taken immediately before killing the animal.

Weights were taken of all sows at regular intervals.

All were negative to the complement fixation test for contagious abortion as were all hogs kept on the premises throughout the duration of the investigation. All appeared healthy at all times.

The animals were maintained under conditions that afforded reasonable opportunity for normal growth and development.

THE ANIMALS STUDIED

Twelve sows were killed at various stages of the oestrous cycle. These are arranged in order of progressive phases of the cycle as judged by the behavior of the animal, and by external signs including an examination of the vestibule at the previous heat and at the time of killing. The duration of the oestrous cycle has been obtained for each individual (except No. 10) and the animals are placed in sequence as to the number of days since the last heat period. Where the period of heat has been two days or less the time noted is that since the last sign of heat. Where the period has lasted three days the time is taken from the second day. The number of days till the next expected heat is based on the length of the cycle characteristic of the individual.

Thus the animals studied histologically may be tabulated.

TABLE 2.—TABULATION OF GENERAL DATA ON ANIMALS STUDIED

Cycle sequence	Sow	Days since last heat	Days estim. till next heat	Weight at death (lbs.)	Age of sow at death
1*	11R	12	11	280	1y. 2m. 20d
2	4R	16	3	445	1y. 8m. 11d.
3	31Ad	16	2-3	484	1y. 11m. 12d
4*	50	19	First Signs	335	1y. 4m. 16d
5	7Rs	20	In heat—2nd day	253	1y. 0m. 9d
6*	8R	19	In heat—2nd day	272	1y. 8m. 24d.
7	11P	1	18	312	1y. 0m. 23d
8	3P	2	19-20	228	0y. 11m. 2d.
9*	4P	4	15-16	282	0y. 10m. 4d.
10	10	4	-----	197	0y. 9m. 21d.
11	9R	7	14-15	387	1y. 9m. 10d.
12	5R	10	11-12	381	1y. 10m. 27d.

*These animals are described in detail.

That the findings may be presented as clearly as possible a description of four animals follows. The cases described are typical of four stages in the oestrous cycle in non-pregnant swine.

The Dioestrous Stage.—It seems convenient to consider first a representative of the dioestrous interval, 11R. This sow showed signs of heat April 8-10, and 30, 1924, May 24-26, June 17-18, and July 11-12, periods of 21, 25, 24 and 24 days respectively. She was killed July 24, 1924.

External Signs.—These were contracted labia, muscles of vestibule tight, the walls pink and moist, the vulvo-vaginal sphincter contracted, and mucus scant.

Vaginal Content.—(a) Vestibule: a few polymorphonuclear

leucocytes and several nucleated epithelial cells, differing in their reaction to the stains, composed this smear. (b) Vagina proper:—very few cells, only an odd leucocyte and occasional basic staining epithelial cells made up this smear.

Histology of the Vetsibule.—There were many leucocytes in the stroma where the latter was covered by the thicker portions of the epithelium. When there were only 3-5 layers of epithelial cells the leucocytes were few in the stroma beneath. The basement membrane was missing where the leucocytes were congregated but was very distinct for the most part. There were usually from three to five layers of cells in the epithelium, though between the papillae extending into the epithelium a thickness of eleven cells was common, while here and there as many as twenty-six cell layers could be counted. The two or three cells adjoining the stroma took the nuclear stain strongly, the next fourteen layers were acid in staining reaction and were lightly infiltrated with leucocytes. There was a faintly stained zone just above the germinativum which included the first one or two layers of these fourteen. Above the acid-staining area there were ten additional cell layers which reacted only slightly to the stains; this almost cornified mass appeared only occasionally in the sections. One could see nucleated cells and leucocytes already desquamated but fortunately fixed in the material sectioned (Plates I and VI A).

Histology of Vagina.—The block studied was from the floor of the vagina about 5 cm. anterior to the vulvo-vaginal sphincter. The leucocytes in the stroma just beneath the basement membrane were few, though their number was considerable at some places. The basement membrane did not stand out distinctly and in many places was not perceptible. Three to six layers of cells were found throughout most of the epithelium. These took up both the hematoxylin and eosin, the deepest cells appearing bluer than the more superficial. There were also areas of thicker epithelium of 7-8 cell layers but here were found clumps of leucocytes and débris in clear lacunae. Very few free cells were found though some appeared at the point of desquamation (Plate VII A).

Papillae were rare in the stroma of the vagina proper as compared to the vestibule.

The right ovary contained six large red corpora lutea measuring in diameter 11, 11, 10, 10, 9, 6 mm. respectively or an average of 9.5 mm. There were six white corpora lutea from the previous ovulation, 3, 3, 3, 3, 2, 2 mm. in diameter, an average of 2.7 mm.

Forty-six follicles were present, measuring 4, 3, 3, 3, 3, 3, 2, 2 mm., the rest 1-2 mm. in diameter, an average of 1.61 mm. (Plate X).

The left ovary was very similar. There were here nine red corpora lutea, not yet solid in the center; these measured in diameter 11, 10, 10, 10, 10, 10, 10, 10, 9 mm., an average of 10 mm. There were about the same number of white corpora lutea as in the right ovary, but no count was made on these. There were forty-four follicles six of which were somewhat darker than the rest. The average diameter of these six was 4.0 mm. and of all the follicles 2.1 mm. This ovary weighed six grams.

The Early Oestrous Stage.—Sow 50 showed signs of heat December 2, and 22, 1924, and January 12, 1925. She was just coming into heat when killed January 31, 1925.

External Signs.—After some teasing she stood for the boar, but he was not permitted to copulate. Two and one-half hours later she was killed. At the time of killing the labia were swelling but had not reached the full size characteristic of the sow at the height of oestrus; the vestibular muscles had not fully relaxed, the walls were red and fairly watery, the vulvo-vaginal sphincter had not yet relaxed; mucus was scant.

Vaginal Content.—(a) Vestibule: Polymorphonuclear leucocytes in fair numbers, several bluish nucleated epithelial cells, and a few unstained cornified elements made up this smear. (b) Vagina: a few large polymorphonuclear and mononuclear leucocytes, a very small number of nucleated epithelial cells taking some acid stain, and an odd clear cornified element constituted the smear.

Histology of the Vestibule.—Several leucocytes were present in the stroma; the basement membrane was distinct. There were large papillae with many secondary ones extending into the epithelium which varied from 8 to 22 cells in thickness, 11-15 being the commonest. The stratum germinativum stained a deep blue while the more superficial layers tended to a reddish purple. The surface layer seemed fairly intact, though there were some few ragged portions where some cells with pycnotic nuclei and a few leucocytes were congregated. Few, if any, leucocytes were present in the greater part of the epithelium (Plate VI B).

Histology of the Vagina.—Leucocytes in fair numbers permeated the stroma particularly just beneath the epithelium. The blood vessels appeared distended and perforated the whole stroma. The basement membrane was clear and distinct. The cells of the

germinativum were tall, narrow and appeared crowded which might indicate rapid proliferation in this region. There were 10-15 layers of cells in the epithelium, and the greater part was near the fifteen cell thickness. The cells reacted to both stains except the two or three surface layers whose nuclei stained black. The free surfaces of the superficial cells stretched out into the lumen till the cells here appeared low columnar. There was an occasional free cell but these were rare.

The right ovary had no red corpora lutea. Seven white corpora lutea measured in diameter 7, 7, 7, 6, 5, 3, 3 mm., an average of 5.4 mm. There were eighteen follicles measuring in diameter 14, 13, 12, 11, 11, 11, 10, 8, 6, 5.5, 1, 1, 1, 1, 1, 1, 1 mm. respectively. The seven large follicles averaged in diameter 11.7 mm. (Plate X).

The left ovary was very similar. There were no red corpora lutea, and the eight white ones measuring 7, 6, 6, 6, 5, 5, 4, 4 mm., averaged 5.4 mm. in diameter. There were five follicles, all large, measuring 13, 12, 12, 11, 11 mm. respectively—an average of 11.8 mm. There were two brownish spots on this ovary, probably old corpora lutea; the diameters of these were 4 and 3 mm. respectively. Also a mass of what looked like old corpus luteum tissue was present.

The Late Oestrous Stage.—Sow 8R was bred May 15, 1924, farrowed eleven live pigs September 5, 1924, and the pigs were weaned eight weeks later. She was in heat January 15, 1925, and again February 2 and 3, and was killed the afternoon of February 3, 1925.

External Signs.—She was very receptive to the boar at time of killing; other signs were labia flabby, vestibular muscles partially relaxed, mucosa red and glistening and moist to watery, vulvo-vaginal sphincter quite relaxed, some thick white mucus.

Vaginal Content.—(a) Vestibule:—several polymorphonuclear leucocytes, many nucleated epithelial cells almost cornified, and a few cornified elements constituted the smear. (b) Vagina: leucocytes in fair numbers and a few eosin-stained epithelial cells were in this smear.

Histology of the Vestibule.—The stroma contains several leucocytes and these were especially numerous just below the distinct basement membrane. The epithelium is even thicker than that of Sow 50, from 11 to 20 layers of cells being usual. These cells had a slight affinity for the eosin. Leucocytes had infiltrated the epithelium in considerable numbers and here and there were to be found clumps of leucocytes. The papillae did not extend far into the epithelium. Very few cells seemed to be free (Plate VI C.)

Histology of the Vagina.—The stroma of the vagina contained some leucocytes scattered around in it, and again these congregated near the epithelium. The basement membrane was faint or absent. The epithelium ranged in thickness from 14-26 layers of cells which in the stratum germinativum stained with the basic dye while the more superficial cells were eosin-stained. Some lightly stained cornified cells appeared on the very surface of the epithelium. Leucocytes had invaded the epithelium and were noticeable throughout. They occurred in fair numbers, (Plate VII B).

The right ovary had one follicle evidently partly collapsed. There were eleven white corpora lutea, measuring 6, 6, 5, 5, 5, 5, 5, 4, 4, 4, 3 mm.—average 4.7 mm. One follicle 8 mm. in diameter was present together with nineteen others 1-2 mm. each, (Plate X.)

The left ovary presented a somewhat different picture. There were eleven fresh corpora lutea not yet redistended measuring in diameter 7, 6, 6, 6, 6, 6, 6, 5, 5, 4, 3 mm.—average 5.5 mm. Also fourteen white corpora lutea were noted, 6, 6, 5, 5, 5, 5, 5, 5, 4, 4, 4, 3, 3, 3 mm., or an average diameter of 4.5 mm. There were twenty follicles between one and two millimeters in diameter and evidently more that were smaller. This ovary weighed five grams. Eleven eggs (total number) were recovered from the Fallopian tube.

The Metoestrous Stage.—Sow 4P showed signs of heat December 31, 1923, January 20, 1924, and February 7-8, 1924 and was killed February 12, 1924.

External Signs.—These were contracted labia, muscles of vestibule only slightly relaxed, the mucosa pink and moist, and containing quite a little mucus.

Vaginal Content.—Vestibule: several polymorphonuclear leucocytes, many nucleated cells bunched together, some red, some blue, and some having affinity for both stains, and a few cornified elements made up the smear.

Histology of the Vestibule.—Certain large areas in the stroma teemed with leucocytes, the basement membrane was gone in many places and the epithelium was infiltrated with polymorphs. In places the epithelium had desquamated till only one or two cell layers were found. Where the epithelium was high the cells took the eosin very markedly save those in the germinativum. Many cells were free or almost so and these showed variable affinity for the stains (Plate VI D).

Histology of the Vagina.—Few leucocytes were present in the stroma except in the areas below the thicker parts of the epithe-

lium where they occurred in considerable numbers. The basement membrane either showed faintly or was gone, and especially was its absence noted where the leucocytes abounded. There were from three to five cell layers for the most part, though the thicker portions of the epithelium had as many as fourteen to fifteen layers. This high epithelium with its eosin-stained cells appeared to be disintegrating and sloughing off, leaving five or fewer layers which showed somewhat greater affinity for the hematoxylin. Leucocytes in fair numbers were seen in the epithelium. The free cells had been desquamated and they reacted variously to the stains; some leucocytes were also free (Plate VII C and D).

The right ovary had six red corpora lutea, 11, 10, 10, 9, 8, 8, mm., respectively, or an average of 9.3 mm. These were filled with a dark gel which squirted when pressure was applied to the walls. Six white corpora lutea, 5, 5, 4, 4, 4, 4 mm., an average diameter of 4.3 mm., were present. The follicles consisted of one bluish 2.5 mm., three clear 2, 2, 1 mm., and three almost submerged. This ovary weighed 4.5 grams (Plate X).

The left ovary, somewhat similar to the right, was sectioned and fixed without any measurements being taken.

CYCLIC CHANGES IN THE NON-PREGNANT SOW

External Signs.—In the dioestrous interval the external labia (or vulva) were usually wrinkled and contracted. The muscles of the vestibule were only slightly relaxed, the walls were normally moist and a healthy pink, little or no mucus was found in the passage. At this time the vulvo-vaginal sphincter muscle was only semi-relaxed.

About two days ($0-3\frac{1}{2}$ days) before oestrus the vulva had swollen till at the onset of heat practically all the wrinkles had disappeared and the labia had reached a much greater size. The muscles of the vestibule relaxed some 2 days (0-4 days) before heat; in the dioestrus the walls were firm but just prior to and during the early hours of heat the vestibule became very open and roomy. The walls of this passage became very watery and red and the vulvo-vaginal sphincter relaxed markedly.

These changes reached a climax in oestrus or heat when the animal grew restless and sometimes made considerable noise in the pen by its characteristic grunt. The sow in oestrus might mount its mates in the pen, or, as was more often the case, she was the recipient of such behavior. This was not always true,

however, for the animal might go through the oestrous period without exhibiting restlessness or mounting.

The sow usually remained in heat somewhat longer than one day, nearly two days in fact, and occasionally one remained in heat for three days. An example of a sow remaining in heat for three days is that of 5R which stood well for the boar twice daily. March 20, 21, and 22, 1925, refusing him the evening of March 19 and the morning of March 23. Plate II is a graphic representation of the changes noted in this sow from March 9 to March 31, 1925.

With the passing of oestrus the swelling in the vulva went down, the muscles of the vestibule contracted; frequently this contraction was very marked for a day immediately following heat but a semi-relaxed tone was soon reached. Now the serous secretion was lessened, often so much so that the walls appeared almost dry, and the blanching of the walls indicated the subsiding of the congestion.

With the onset of oestrus the whitish mucous secretion was increased at times very noticeably, though usually the discharge was not excessive. It was only during the week preceding heat that it was usual to find mucus very scant or entirely wanting. An abundant mucous secretion throughout the greater part of the cycle might be indicative of a pathological disturbance. Such was the case with one sow not included in this report, hydrosalpinx being discovered at autopsy.

Indeed the external signs of oestrus were outstanding as a rule. This is shown rather clearly in Plates II, III, and IV. Animals 4R and 8R were gilts (had never farrowed) at the time these observations began. Sow 4R was receptive to the boar April 24, 1924; from May 13 evening until May 14 evening she was restless and gave evidence of being in heat; and on June 3, 1924, she came in heat again. Sow 4R was never bred. Sow 8R showed no uneasiness or mounting April 5, 1924, nor any such excitement near this date. However, April 24 she was receptive all day and was bred. Again on May 15 this sow came in heat and was bred a second time, and pregnancy followed. This affords an example of a sow experiencing oestrus without giving "out-spoken" external signs described by Corner⁹ as regularly present.

The means adopted for recording the observations made were somewhat crude but met the situation fairly satisfactorily. The vulva was reported as contracted (C), swollen (S), and as intergrades of these conditions as quarter, or half swollen. The same

system was applied throughout; the muscles of the vestibule were tight (t), relaxed or open (op), or partially so; the serous secretion gave a watery (w), moist (m) or dry (d) appearance to the mucosa; the color red (R), pink (P) or white (W); the mucous secretion scant (1) or wanting (0) up to abundant (4); and the vulvo-vaginal sphincter tight (t) or open (op) or in an intermediate stage of relaxation. These abbreviations appear in Plates II, III and IV.

The Vaginal Content.—As noted in Plate I the vagina proper in the sexually mature sow was 8-10 cm. in length from the vulvo-vaginal sphincter forward to the area studded with hillock-like prominences which marked the posterior region of the os uteri. The vestibule extending from the external labia to the sphincter had approximately the same length as the vagina itself. From each of these regions samples of the contents were taken and examined microscopically as already intimated in Methods above.

The dioestrous smear from either region consisted of varying numbers of polymorphonuclear and mononuclear leucocytes, nucleated epithelial cells that had a tendency to take the basic stain and a few cornified elements either acid-staining or non-staining.

During the latter half of the dioestrus the leucocyte count was at its minimum. Not often, and certainly not for any length of time was there a total absence of leucocytes from the smear.

During late oestrus the leucocytes in the smear increased in number very suddenly and not infrequently occurred at this time in large masses so that when viewed under the low power they covered a large portion or all of the field. This sudden influx of leucocytes was more sharply defined and occurred with greater regularity in the smear from the vagina proper than in that from the vestibule. Leucocytes were most numerous in the smear from late oestrus till 2-4 days after heat. It required from 2-8 days after oestrus for this "leucocytosis" to subside to the dioestrous state, though in 4-5 days this condition was usually approximated.

The nucleated cells from the squamous epithelium of the vestibule and vagina were thrown off in quite as regular fashion throughout the cycle as were the leucocytes. In the early hours of heat there was to be noted no particular change in the number or kind of epithelial cells desquamated as compared with the late dioestrous stage. But the count rapidly increased towards the end of the heat period and by the second day following oestrus the peak of the curve was reached when clumps of deep acid-staining epithelial cells, small-sized ones predominating, appeared in the

smear. By the end of the first week after heat the dioestrous smear was again obtained. There was some fluctuation in the number of nucleated cells included in the smears, and here again the vaginal smear proper was somewhat more uniform, though as already pointed out, the greater part of the sloughing of these cells occurred during the seven days following heat.

The cornified epithelial elements occurred in very small numbers throughout the cycle there being no particular stage that seemed to be devoid of them, though frequently they were absent from the smear. Evidently the great mass of the epithelial cells were sloughed before they lost their nuclei and became completely cornified.

In Plates II, III and IV readings from smears of the vaginal contents of the three animals 5R, 4R, and 8R are presented. Three cycles are included in each of 4R and 8R, when smears were taken on alternate days, and one cycle is shown for 5R with smears taken at closer intervals. The leucocytes, nucleated epithelial cells, and cornified elements for each of the vestibule and vagina are graphed as these were recorded. Where the count was very small the reading was for instance "Leuc. 1", if a few were scattered throughout the field "Leuc. 2" as in Plate V B, if several "Leuc. 3", if very abundant "Leuc. 4". This same system of presentation applies to the other cellular contents and refers to estimates rather than to actual counts.

Note in Plate IV that the first oestrus of 8R, April 5, though not marked by the usual restlessness or mounting, did show signs of oestrus as brought out by microscopical examination of the genital passage.

Thus the vaginal contents of the sow underwent cyclic changes in relation to oestrus. And it is noted also that the more easily procured vestibular smear, though presenting cyclic changes, was not as dependable, nor as precise as the smear from the vagina proper.

The Histology of the Vestibule.—The stroma of the vestibule was infiltrated with leucocytes continually though the number varied. Leucocytes occurred in smallest numbers in Sow 50 in the series studied, just at the onset of oestrus. In 7Rs about the same number was found as in the stroma of 50; following ovulation this number was augmented as found in 8R (late oestrus) and the day after heat very many polymorphs occurred in the stroma. This rather heavy leucocytosis continued till the fourth day after the cessation of heat when this phenomenon subsided

appreciably. Following the fourth day (4P and 10) the leucocytes persisted in the stroma in moderate numbers till about the next heat period, having become comparatively scarce in the early hours of oestrus (Plate VI B).

The basement membrane of the vestibule seemed to undergo changes that could be correlated with the oestrous cycle. In the mid-dioestrus it was only fairly distinct (11R). This membrane stood out more clearly with the approach of oestrus, was very distinct during oestrus, and the day after oestrus appeared quite as distinct but was not entire for it was absent in the papillae of the stroma. Following oestrus this membrane seemed to loosen, the fibers composing it having separated somewhat, and by the fourth day after heat the membrane, as such, appeared quite faint.

The epithelium of the vestibule was stratified squamous and the thickness of it varied with the stage in the oestrous cycle. It is difficult to give a specific thickness at any one time so the extremes are given and the number of layers of cells that most nearly characterizes the thickness is given as well, and in the following table this latter number is shown in *italics*. (Plate VI.)

TABLE 3.—EPITHELIUM OF VESTIBULE

Sow	Days since last heat	Layers of cells
11R	12	3-11-26
4R	16	1- 6-11-16
31Ad	16	3- 8-11-14
50	19 (heat)	8-11-15-22
7Rs	20 (heat)	8-13-14-20
8R	19 (heat)	11-20
11P	1	11-15-32
3P	2	3- 7- 8-15
4P	4	2-24
10	4	3- 4-15-20
9R	7	2-17
5R	10	4- 5-18

Beginning with 11R it is noted that the characteristic thickness of the epithelium varied from 3 to 11 cell layers (Plate VI A). With the approach of oestrus there was some cell proliferation, but this was not marked until immediately before heat. Some growth continued until at least late oestrus (8R). It is important to note also that up to this time (11R-8R) the epithelial cells had shown a rather marked affinity for the basic dye, especially was this true with those portions of the epithelium considered typical of the individual in question. During and following heat for at least a week the cells exhibited an increased affinity for the eosin.

This increased acid reaction was accompanied by nuclear shrinkage, and marked degeneration of the whole epithelium with a tendency to cornification of the surface layers.

Some cells were being sloughed throughout practically the whole cycle though there were fewer at oestrus than at any other time (Plate VI B and C). However, on the second day following heat marked desquamation of the cells began and this phenomenon increased rapidly in intensity. Sow 4P at four days after heat had great masses of cells sloughed from the vestibular epithelium, thus only two or three cells remained in places while in other portions not yet cast off the maximum thickness was twenty-four cell layers (Plate VI D). The greatest amount of the sloughing occurred from the second to the fourth day after heat, but the process went on in a moderated degree, ridding the mucosa of the cells of one generation to be followed by the growth of another set.

Closely correlated with this desquamation on the part of the epithelium was the infiltration into it of leucocytes from the stroma. Only a comparatively small number of leucocytes were present in the vestibular epithelium of 11R except in the thickest portions where the polymorphs were numerous. In 4R, three days prior to the next oestrus (estimated), leucocytes were noticed in the stratum germinativum having evidently just migrated up through the basement membrane from the stroma (Plate VI B). The leucocytosis in the epithelium increased in intensity gradually throughout oestrus and reached a maximum the second to the fourth days after heat. An occasional clump of leucocytes was seen at various stages, especially was this so about the tenth day after oestrus in the thicker portions of the epithelium which as yet had not been desquamated (Plate VIII A).

The Histology of the Vagina.—The stroma of the vagina proper contained leucocytes at nearly all times. The usual small number was augmented during the first four days after heat. Leucocytes appeared in smallest numbers in the vaginal stroma from the middle of the dioestrous interval to the day after heat.

The basement membrane of the vagina was most distinctly discernible a few days before heat (4R) till during oestrus. With the passing of oestrus this membrane loosened as in the vestibule, having become faint or invisible in places. This interrupted condition of the basement membrane continued throughout the met-oestrus. By the twelfth day after heat it again appeared practically intact and became fairly distinct by the sixteenth day.

The vaginal epithelium was stratified squamous and varied in thickness in relation to oestrus. Table 4 presents the number of layers of cells found in the vaginal epithelia of the animals studied (Plate VII).

TABLE 4.—EPITHELIUM OF VAGINA

Sow	Days since last heat	Layers of cells
11R	12	<i>3-6</i>
4R	16	<i>3-4</i>
31Ad	16	<i>4-5</i>
50	19 (heat)	<i>8-12-15</i>
7Rs	20 (heat)	<i>9-13-16</i>
8R	19 (heat)	<i>10-17-20-26</i>
11P	1	<i>11-20-25</i>
3P	2	<i>9-12-22</i>
4P	4	<i>2- 5-15</i>
10	4	<i>3- 6- 9-15</i>
9R	7	<i>5- 9-12</i>
5R	10	<i>3- 5-12</i>

The italic figures indicate the typical thickness.

It is noted from this table that the epithelium of the latter half of the dioestrus was very low, three to six cells for the most part, while with the onset of oestrus there was an appreciably thicker epithelium, twelve to fifteen cell layers. This growth continued during the oestrous period. About the fourth day following heat there was heavy sloughing (4P) and the epithelium became much lower (Plate VII C and D). Sows 10 and 9R do not show this desquamation quite so markedly.

The stratum germinativum showed affinity for the basic stain for practically the whole cycle. The more superficial cells took the blue hematoxylin just before oestrus. In oestrus, and soon after, the epithelial cells took more of the eosin. The superficial layers in areas of greatest thickness (15-26 cells) appeared to take little or no stain.

In contrast to the flat superficial layers of the mid-dioestrus, the surface layer of the vaginal epithelium was found to be low columnar in type in late dioestrus (4R) (Plate VIII B). This condition existed till ovulation when it appeared that this layer was sloughed, in part at least, having left a ragged surface to the mucosa as seen in cross-section.

Leucocytes occurred in smallest numbers in the vaginal epithelium in the late dioestrus. A few small clumps of leucocytes were seen in early oestrus in the germinal layer, possibly just en-route through the basement membrane to the more superficial

layers. The leucocytic invasion continued throughout oestrus and reached its height in the metoestrus. Marked desquamation had begun by the fourth day after heat. Where the superficial layers were not desquamated they contained many leucocytes in clumps in clear lacunae (Plate VII A). However, by the sixteenth day after oestrus the sloughing seemed about completed, only new growth remained and few or no leucocytes were present (Plate VIII B).

The Histology of the Uterus.—The lining membrane rests on a stroma of areolar connective tissue, which in turn lies on the muscularis (inner circular and outer longitudinal muscle layers).

The uterine stroma became slightly edematous in the late dioestrus and in prooestrus this condition became very marked. The edema continued in a lesser degree till ovulation but disappeared immediately after heat. Leucocytes were present in the stroma at all times though their number was greatly augmented from late dioestrus till at least four days after heat.

The basement membrane was distinct throughout the cycle.

The epithelium of the uterus was really simple columnar in type but the pseudo-stratified condition was characteristic of this tissue for about a third of the oestrous cycle, namely, from the prooestrous stage till nearly a week after heat. Cilia were found on the epithelial cells in the crypts and glands but not on the free surface. The epithelial surface was quite hillocky in the 7-day and 10-day stages after heat. Two or three days before the onset of oestrus the epithelial cells grew in height very rapidly. This growth continued till the maximum was reached towards the latter half of the week following heat, after which time there was a return to the low columnar form. The glandular epithelium did not appear to change much in height with respect to the oestrous cycle.

One very striking characteristic change in the uterus was the very marked vacuolar degeneration in the prooestrus subsiding quite appreciably shortly afterwards till late oestrus when no vacuoles were evident. The leucocytes also appeared more numerous in the prooestrous epithelium but mostly disappeared after the fourth day following heat. A clear zone like a narrow strip appeared between the basement membrane and the basal ends of the epithelial cells in late heat and for a day after, probably another evidence of degeneration. Again, in very late dioestrus and till after the fourth day following heat the epithelial cells appeared very crowd-

ed, were compressed laterally, and narrow dark cells were to be found squeezed between other cells of the epithelium (Plate IX B).

The following table gives the thickness of the uterine epithelium, that is, the height of the uterine epithelial cells in the animals studied. For the sake of comparison some of Corner's⁹ data are also presented.

TABLE 5.—EPITHELIUM OF UTERUS

Sow	Days since last heat	Height of epithelium (micra)	
		McKenzie's data	Corner's data
11R	12	13-23	15-20
4R	16	19-23	15-20
31Ad	16	28-42	15-20
50	19 (heat)	21-42	25-30
7Rs	20 (heat)	30-39	25-30
8R	19 (heat)	23-36	25-30
11P	1	16-34	35-40
3P	2	23-42	35-40
4P	4	23-51	35-40
10	4	36-63	35-40
9R	7	33-45	35-40
5R	10	8-21	20-45

The Ovary.—A transparent ruler graduated in millimeters was used to measure the parts of the ovary. Weights were taken also in most cases. Table 6 summarizes the findings and Plate XI gives a graphic picture of the same.

As noted from the number of corpora lutea the contention that the animals were of good breeding is borne out from the standpoint of fecundity.

The Corpora Lutea.—When the mature follicles ruptured at the time of ovulation, the diameter of these follicles was reduced from 11-12 mm. (Sow 50) to 5-6 mm. (8R). Soon the walls of the collapsed follicles were redistended, while the rupture points remained visible for some days. The writer injected physiological saline into the fresh corpora lutea of 11P. These distended till a diameter of 10 mm. (size of mature follicle) was reached when the liquid escaped through the old rupture point. The corpora lutea continued to increase in size till the seventh day, and between the twelfth and sixteenth days showed retrogression. This retrogression continued for some time though at the sixteenth day no distinct corpora lutea were noticed from the ovulation of thirty-five days previous though there were indistinct white marks indicating their almost total disappearance.

TABLE 6.—SUMMARIES OF FINDINGS WITH REFERENCE TO THE OVARIES
(SECTION ONE)

Sow (days since last heat)	Ovary	Wt. of Ovary (grams)	Number of corpora lutea	Aver. Dia. of C. L. (mm.)
11R	Rt.	---	6(purple-rp*)	9.5
(12)	Lt.	6.	6(white)	2.7
			9(red)	10.
			6±(white)	2.7
4R	Rt.	---	10(pink)	7.6
(16)	Lt.	---	7(pink)	7.5
31Ad	Rt.	8.7	9(white)	8.3
(16)	Lt.	9.0	6(white)	8.0
50	Rt.	---	7(white)	5.4
(19 heat)	Lt.	7-8	8(white)	5.4
7Rs	Rt.	6	6(white)	3.7
(20 heat)	Lt.	8	7(white)	4.6
8R	Rt.	---	11(white)	4.7
(19 heat)	Lt.	5	14(white)	4.5
			11(red-rp)	5.5
11P	Rt.	---	5(red-rp)	7.4
			6(white)	6.0
(1)	Lt.	3.5	6(red-rp)	6.9
			13(white)	4.2
3P	Lt.	5	6(red-rp)	8.0
(2)			9(white)	5.25
4P	Rt.	4.5	6(red-rp)	9.3
(4)			6(white)	4.3
10	Rt.		5(red-rp)	8.2
(4)			5(white)	4.0
	Lt.	3.4	5(red-rp)	7.8
			3(white)	4.0
9R	Rt.	10	10(red)	10.6
(7)			8(white)	5.25
	Lt.	10	8(red)	10.75
			7(white)	5.0
5R	Rt.	8	9(pink)†	9.2
(10)			4(white)†	3.5
	Lt.	8	10(pink)†	9.6
			6(white)†	3.8

*Rupture point visible.

†C. L. flat, not projecting.

The external color of the corpora lutea changed gradually from a flesh red when fresh to a pink ten days later; there was a transition now to white by the sixteenth day, and the corpora lutea were white at the onset of the next oestrus.

TABLE 6.—SUMMARY OF FINDINGS WITH REFERENCE TO OVARIES.

(SECTION TWO)

Sow Ovary	No. of Follicles	Average Size of Follicles (mm.)	Number of Fol. in largest set	Avg. Size of Fol. largest set (mm.)
11R-Rt.	46	1.6	6	3.2
Lt.	44	2.1	10	3.5
4R-Rt.	55	2.4	7	4.3
Lt.	52	2.16	9	4.1
31Ad-Rt.	26	3.2	6	6.3
Lt.	28	3.8	11	6.6
50-Rt.	18	6.3	7	11.7
Lt.	5	11.8	5	11.8
7Rs-Rt.	24	3.6	6	10.3
Lt.	38	2.8	8	8.75
8R-Rt.	20	1.8	1	8.0
Lt.	20	1.2	20	1.2
11P-Rt.	Few	1-	Few	1-
Lt.	14	1.2	14	1.2
3P-Lt.	15	1.2	1	7.0
4P-Rt.	7	1.2	3	2.2
10-Rt.	14	1.8	10	2.1
Lt.	22	1.6	12	2.2
9R-Rt.	28	2.6	14	3.7
Lt.	52	2.4	18	4.25
5R-Rt.	49	3.3	19	4.7
Lt.	47	3.3	22	4.7

The Follicles.—Immediately after ovulation there were found to be quite a few (twenty in 8R) small follicles between one and two millimeters in diameter. These showed slight growth by the fourth day after oestrus. This increase in size of the follicles continued gradually though the small number of animals here used undoubtedly affects the smoothness of the growth curve of the follicles. Again between the third day preceding oestrus and the onset of heat there was further growth, and this time a very rapid increase in the size of the follicles was noted (from 4-5 mm. in 4R to 11-12 mm. in 50). Possibly this growth continued till ovulation though these data do not warrant such a conclusion.

TABLE 7.—A TABULAR SYNOPSIS

Days since heat	DIOESTRUM 8-15	PROOESTRUM 16-18	EARLY OESTRUS 19 (6 hrs.)	LATE OESTRUS 19-20 (2nd day)	METOOESTRUM 1-7
<i>External Signs</i>					
Labia	Contracted	Swelling	Swollen	Contracting	Contracting
Vest. muscles	Slightly relaxed	Relaxing	Quite relaxed	Contracting	Tight
Vest. walls	Moist, pink, little mucus	Reddening, watery	Congested, very watery, mucus	Red to pink, watery, mucus	Pink-white, moist-dry
V.V Sphincter	Semi-relaxed	Relaxing	Quite relaxed	Contracting	Tight
Behavior	Quiet	Quiet	Restless, receptive to boar	Very receptive, mounts	Quiet
<i>Vaginal Contents</i>					
Leucocytes	No. varies	Very few	A few	Very many	Many
Epithelial cells	No. varies, basic staining	Very few	A few	Many, acid-staining	Many
Cornified cells	Few to none	Few to none	Few to none	Few to none	Few
<i>Histology</i>					
<i>Vestibule</i>					
Epithelium	Low, 2-11 layers, very few leuc.	Growing, 8-11 layers, some leuc.	Thick, 11-15 layers, leuc. increasing	Very thick 11-20 layers, leuc. increasing	2-24 layers, many leuc., sloughing
Basement memb.	Fairly distinct	Fairly distinct	Fairly distinct	Very distinct, loosening	Gone in many places
Stroma	Some leuc.	Some leuc.	Very few leuc.	Some leuc.	Many leuc.
<i>Vagina</i>					
Epithelium	Low, 3-6 layers, few leuc.	Growing, 4-5 layers, leuc. scarce	Thick, 12-15 layers, surface layer columnar	Thick 17-20 layers, acid-staining, some leuc.	3-15 layers, many leuc., sloughing
Basement memb.	Fairly distinct	Fairly distinct	Distinct	Indistinct	Very broken
Stroma	Some leuc.	Few to no leuc.	Leuc. increasing	Some leuc.	Many leuc.
<i>Uterus</i>					
Epithelium	Simple columnar, 8-23 micra; extrusions, 2-4 micra; folded.	Pseudo-stratified; much vacuolar degeneration, 28-42 micra	Pseudo-str., crowded, many leuc., vac. degeneration	Pseudo-str., crowded, 29-39 micra leuc.	Pseudo-str., crowded, 16-63 micra, leuc.
Stroma	Leuc. scarce	Marked edema, some leuc.	Edematous, many leuc.	Very little edema, leuc.	No edema, leuc.
<i>Ovary</i>					
Corpora lutea	Red, max. size; white disappearing	White only, of med. size	White only; med. size	White, med. to small; fresh not redistended	Red growing; white med. size
Follicles	Many, med. size.	Med. size, growing fast	Min. no.; greatest size	Fairly numerous, small; ova in tube.	Very small, growing, many

Animals 8R and 3P each had a large follicle, 7-8 mm. It is likely that these were atretic, especially with 3P, though in the case of 8R this follicle might have been at the point of rupture at the time the animal was killed.

As regards the weight of the ovaries at the various stages, nothing conclusive can be stated since the animals varied somewhat in body weight and age. Still there were indications that the ovary with the large follicles actually weighed more than the ovary of a few days preceding this. However that might be, the ovary with large corpora lutea (red and white) had the maximum weight (9R). The ovaries of the first four days after ovulation had the least weight of all.

TABULAR SYNOPSIS

In Table 7, page 25, appears a tabular synopsis of the data presented in this paper.

GENERAL DISCUSSION

Animals have been used in this investigation that appeared normal in every way at all times, while alive and at autopsy.

The duration of the oestrous cycle has been noted to vary with different individuals, and in the same animal. The cycle has varied from eighteen to twenty-five days in length, and the period of oestrus has lasted from one to three days. This is quite normal for the species according to Struve¹², who found the cycle to be of eighteen to twenty-two days in length most frequently, and oestrus to last two to four days.

Corner and Amsbaugh¹³ describe briefly the external signs of oestrus in the sow. No one to the writer's knowledge has reported observations of external signs in the sow throughout the cycle, with a description of the vestibular passage as observed with the aid of the speculum.

Zupp¹⁴ gives a brief account of the vestibular smears of swine. He states that leucocytes are present for only a few days. This is different from my findings for leucocytes were nearly always present*.

In comparison with other animals studied the sow presents much similarity as regards the vaginal content. The rat, mouse, and guinea pig^{1, 2, 3, 14} have no leucocytes in the smear just before

*In a communication from Doctor H. S. Murphey, as this paper goes to press, information is received that Doctor Zupp finds: "That small numbers of leucocytes may be found throughout the cycle and many in the heat period."

oestrous; Murphey^{10, 11} reports that in the cow there are practically no leucocytes in dioestrus; and Corner¹⁶ records in the case of *Macacus rhesus* a diminution in the number of leucocytes in the vaginal smear, occurring 10 to 15 days before the onset of menstruation, that is, just prior to ovulation should this event take place. In the case of the sow, the latter half of the dioestrus affords the minimum leucocyte count.

Again, heavy sloughing of epithelial cells is found to occur in the monkey¹⁶ and in the sow at relatively the same periods, namely the interval following ovulation. Murphey¹⁰ finds epithelial cells in the "post-estrus" in the cow, evidently in large numbers. In the rodents a desquamation of cornified elements occurs in the metoestrus. These would correspond to the nucleated epithelial cells in the monkey, cow and sow. It is true that in the sow these epithelial cells lack some of the affinity for the hematoxylin stain that the cells of the late dioestrus had, but only a few remain in the tract until cornified.

The only account of cyclic changes in the vestibular epithelium found in the literature is that by Murphey¹¹ on the cow. He finds the maximum thickness of the epithelium in the prooestrus, and in the same stage, though somewhat later, marked desquamation and a heavy leucocytic infiltration. This differs from what has been found in the sows here reported. Rather is the maximum thickness of the sow's vestibular epithelium found during oestrus, and the desquamation and leucocytic infiltration do not reach their maxima till the second to the fourth day following heat.

Descriptions of the cyclic changes in the vagina are more numerous: Stockard and Papanicolaou³ and Courrier⁵ on the guinea pig, Long and Evans¹ on the rat, Allen² on the mouse, Hartman⁶ on the opossum, and Murphey¹⁰ on the cow. In the vaginal epithelia of all these animals there is described a distinct cornified layer during oestrus (except in the case of the cow where this phenomenon is said to occur in the prooestrus.) This layer is sloughed very soon and a heavy leucocytic infiltration follows. In the sow the cells do not cornify to any marked extent though there is a progressive change on the part of the more superficial cells to take the acid stain throughout oestrus and metoestrus, and it is in the metoestrus that the sow's vaginal epithelium is most infiltrated with leucocytes.

The uterine cycle is briefly referred to in this paper that findings made in this laboratory may be the more closely tied up with those made elsewhere, chiefly by Corner⁹ in his excellent paper of 1921.

His findings in respect to the uterine changes, are for the most part in accord with mine.

In the ovary it seems clear that there is a gradual growth of the follicles accompanied by the elimination of some follicles at all stages in the non-pregnant cycle. It is true that this growth is much more marked in the prooestrus, and possibly early oestrus, than at other times but one is hardly justified in maintaining that at times other than these stages the follicles lie quiescent. That there is growth as evidenced by an increase in diameter of the surface follicles is brought out in Table 6 and Plate XI.

It is evident that there are changes going on in the genital tract of the non-pregnant sow. It is quite as evident that there exists a definite relation between the changes in one organ and those in another and that all may be correlated with the changes in the ovary. That the ovary is the controlling organ has been amply proven by other investigators, notably Allen¹⁷, who has obtained decisive results which localize the production of the ovarian hormone in the follicle of the ovary in the sow. Again, Allen concludes that "the ovum should be considered the dynamic center of the follicle; and the production of this hormone in the ultimate analysis is therefore traceable to the metabolism of the ovum itself." The vestibule and the vagina in the sow show the beginning of the degenerative phase during oestrus, and before oestrus has passed, but after ovulation the signs of this degeneration are unmistakably present, and are of such a nature that one is further justified in asserting that the degenerative phase in the vestibule and vagina begins about the time of ovulation, if not before. That the stimulus to growth in the epithelia of these genital organs, namely the vestibule and vagina, has been appreciably diminished if not obliterated is evidenced in the onset of the degenerative phase occurring not long after oestrus has set in. Undoubtedly the causative force for this growth has to do with the hormone elaborated in the follicles. Coincident with the degenerative phase of the vestibule and vagina is the increase in the proportion of cytoplasm to nucleus in the uterine epithelium, a period of marked secretory activity, which phenomenon has been described by Corner⁹. It would appear that the growth-promoting stimulus is directed for the most part to the vestibule and vagina prior to oestrus and is then shifted to the area of the uterus to prepare that organ for possible pregnancy.

SUMMARY

1. Young, healthy, sexually mature sows of good breeding were used in this investigation.
2. The animals were examined at regular intervals and notes made regarding their behavior, the condition of the vulvar labia, and vestibule. At this time smears were made of the vestibular and vaginal contents. By killing the animals at various intervals following oestrus a series of twelve genital systems was obtained affording material for the study of the various stages.
3. Cyclic changes were found to occur: (a) In the vulvar labia and vestibule as determined by macroscopic examination; (b) In the vestibular and vaginal contents; (c) In the histology of the vestibule, vagina, and uterus. (d) In the ovaries.

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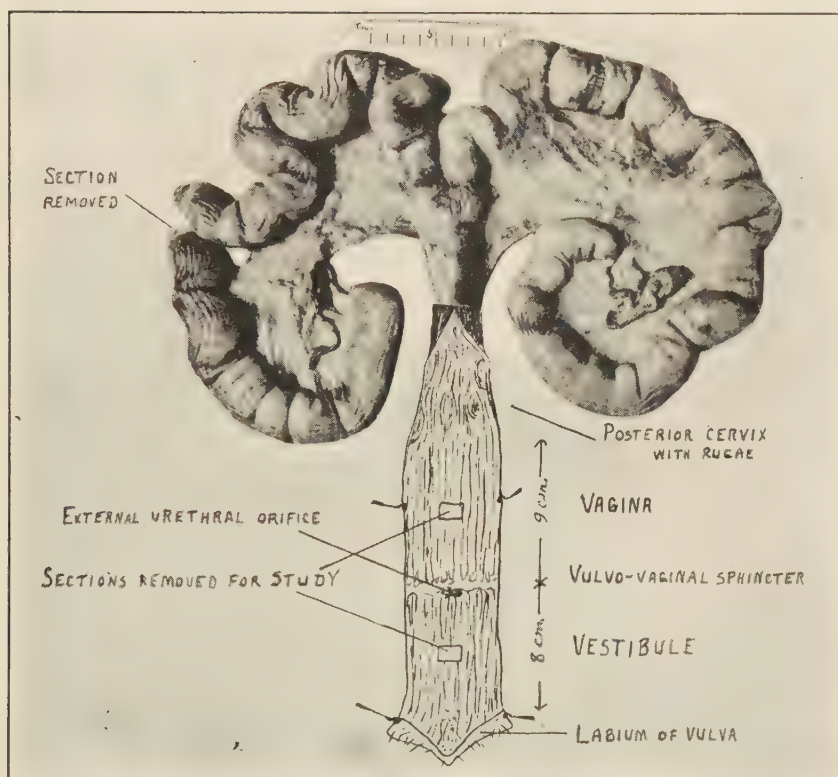


PLATE I.—Dorsal view of the genitalia of the sow with the posterior part open showing the vulvar labia, vestibule, and vagina, and the places from which the blocks were removed for histological study.

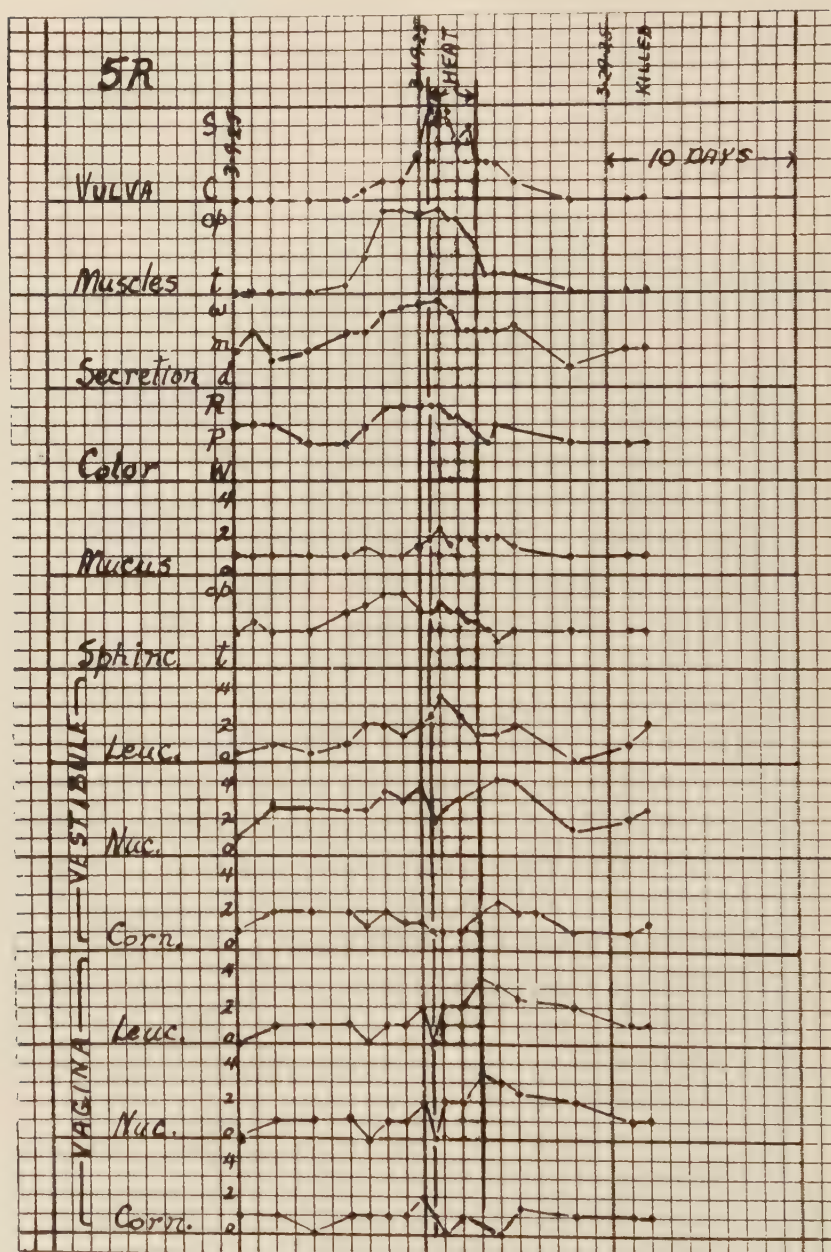


PLATE II.—A graphic representation of the changes recorded in sow 5R throughout one oestrous cycle. Examinations were made twice daily during the three-day oestrous period. The upper six curves refer to macroscopic observations and the remaining six to microscopic readings. The abbreviations are explained in the text, pages 15 to 17.

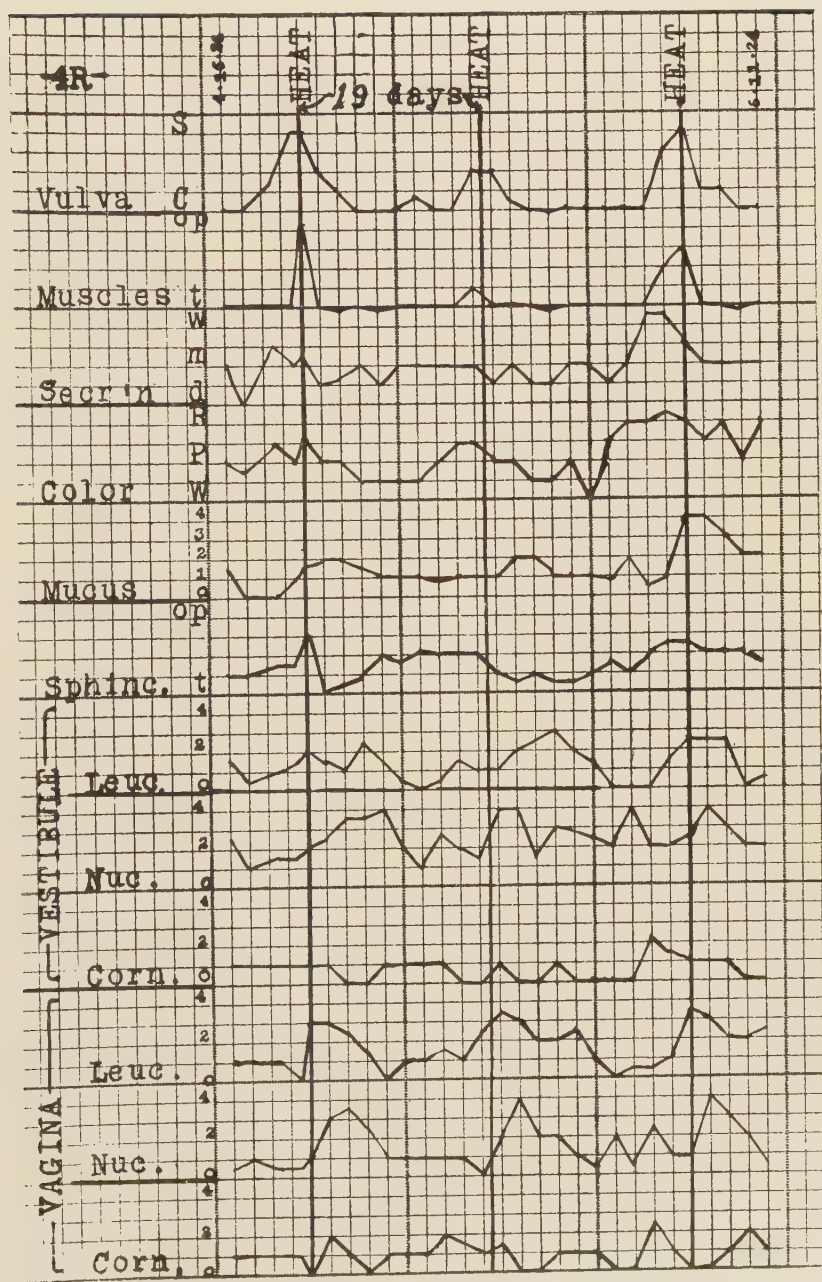


PLATE III.—A graphic representation of the changes recorded in sow 4R throughout three oestrous cycles. Further explanation is made in the text, pages 15 to 17.

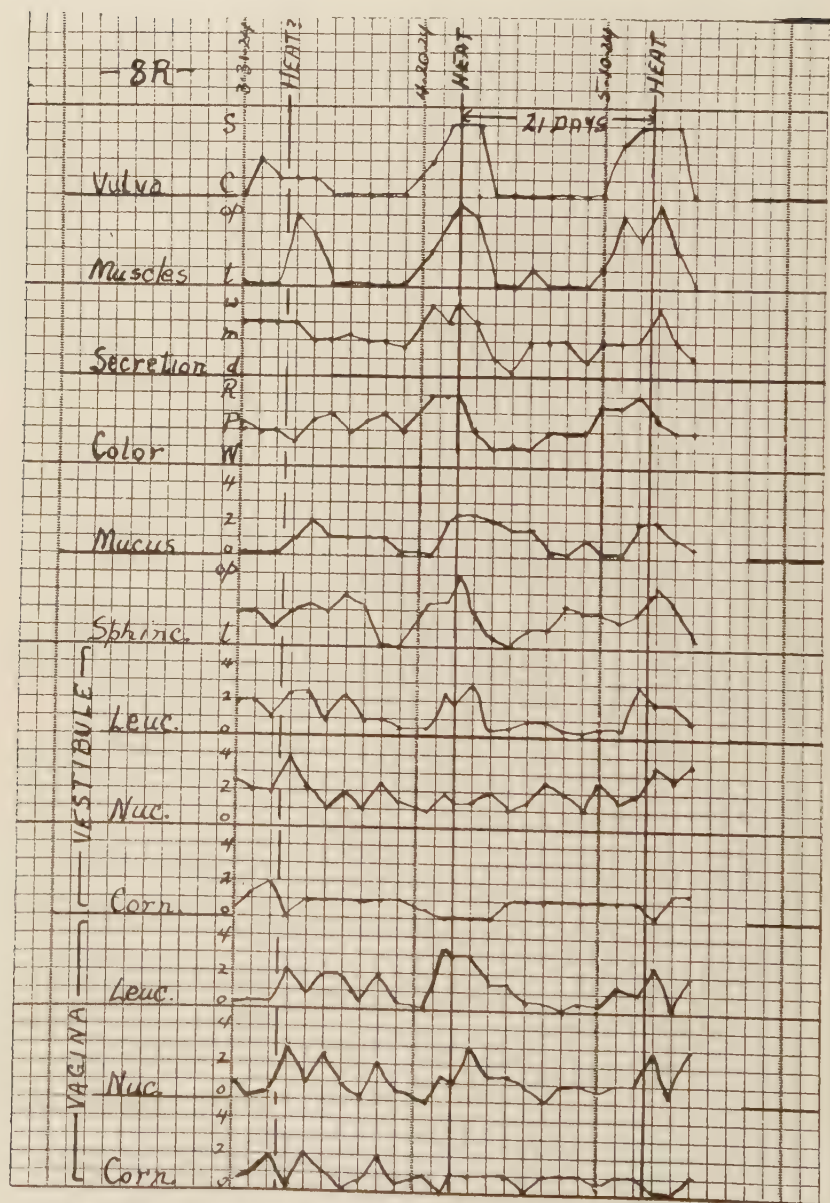


PLATE IV.—A graphic representation of the changes recorded in sow 8R throughout three oestrous cycles. The first heat period was not marked by restlessness or mounting. Further explanation is to be found in the text, pages 15 to 17.

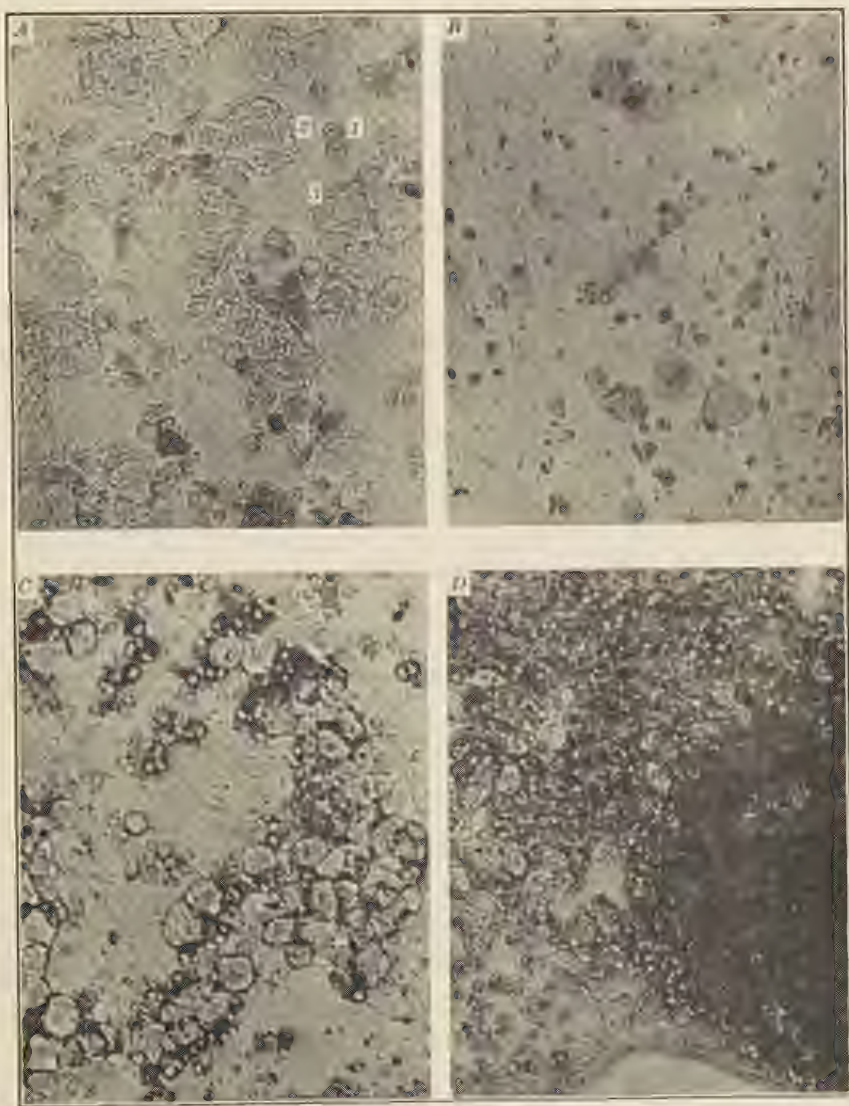


PLATE V.—(A) A smear of the vaginal content illustrating the various types of cells found. The two cells at 1 are polymorphonuclear leucocytes; the large element at 2 is a cornified epithelial cell whose nucleus has disappeared; at 3 may be seen a nucleated cell. The black specks are due to dust particles. Hematoxylin and eosin .335. (B) A dioestrous smear, eleven days after heat. Hematoxylin and eosin. $\times 160$. (C) An oestrous smear. Hematoxylin and eosin. $\times 160$. (D) A metoestrous smear, four days after heat. Hematoxylin and eosin. $\times 160$.

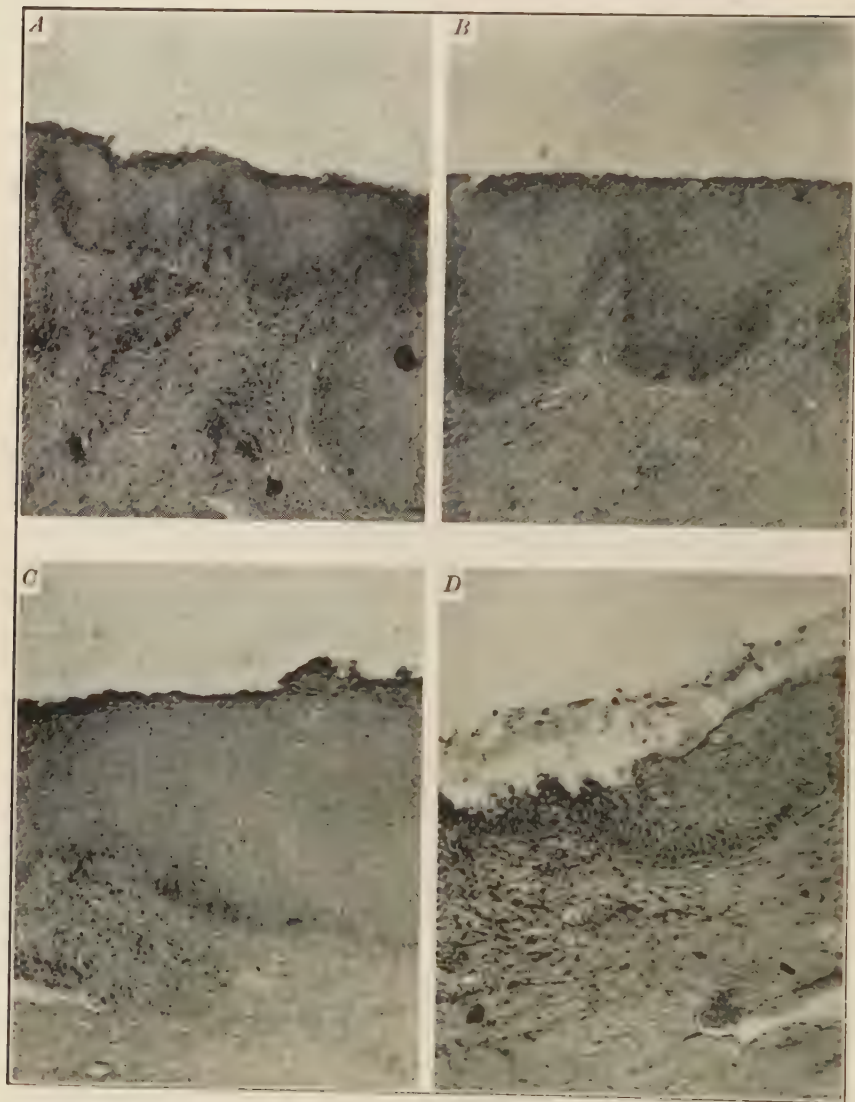


PLATE VI.—Sections of the vestibule cut at 10 micra. Delafield's hematoxylin and eosin $\times 160$. (A) From 11R, twelve days since last oestrus. Note the presence of several leucocytes in the stroma and the indistinct basement membrane. The epithelium consists of 5-11 cell layers. (B) From 50, in early oestrus. Note the small numbers of leucocytes in the stroma and epithelium. There are 8-20 layers of epithelial cells. (C) From 8R, immediately after ovulation, late oestrus. Note the presence of leucocytes in the stroma and epithelium, and the distinct basement membrane. The epithelium is 13-20 cells in thickness. (D) From 4P, four days after oestrus. Note the marked degeneration and heavy leucocytosis in the epithelium, and some leucocytes in the stroma. The epithelium varies from 3 to 16 cells in thickness.

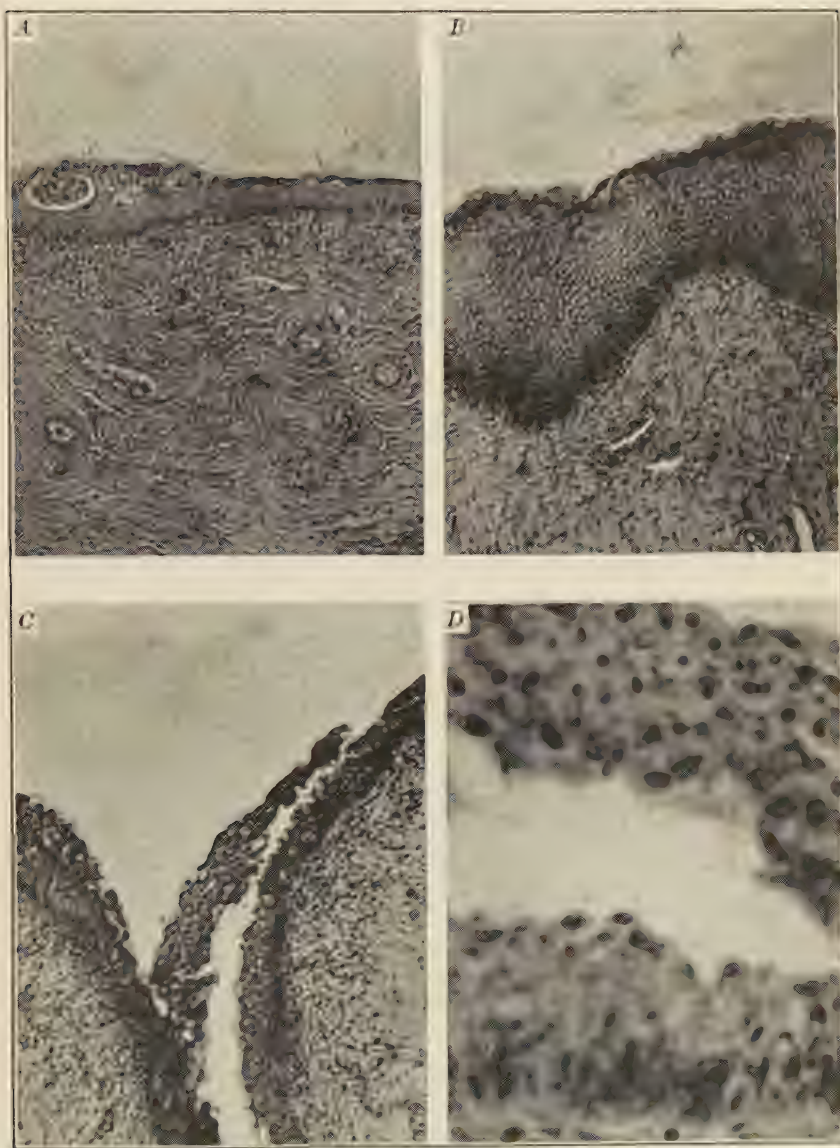


PLATE VII.—Sections of the vagina cut at 10 micra. Delafield's hematoxylin and eosin. (A) From 11R, twelve days after oestrus. Note the low epithelium, 3-6 cell layers, the leucocytes in the clear lacunae where the epithelium is somewhat thicker than in other places, and the small number of leucocytes in the stroma except beneath the higher epithelium. $\times 160$. (B) From 8R, in late oestrus immediately after ovulation. Note the thick epithelium, 14-22 cell layers, the basement membrane just fairly distinct, a few leucocytes in the stroma and some in the epithelium. $\times 160$. (C) From 4P, four days after oestrus. Note the marked sloughing of the epithelium, the presence of several leucocytes in the stroma and in the disintegrating epithelium. $\times 160$. (D) A portion of the tissue shown in VII C at 670 magnifications. Note the desquamated cells (upper area) are nucleated.

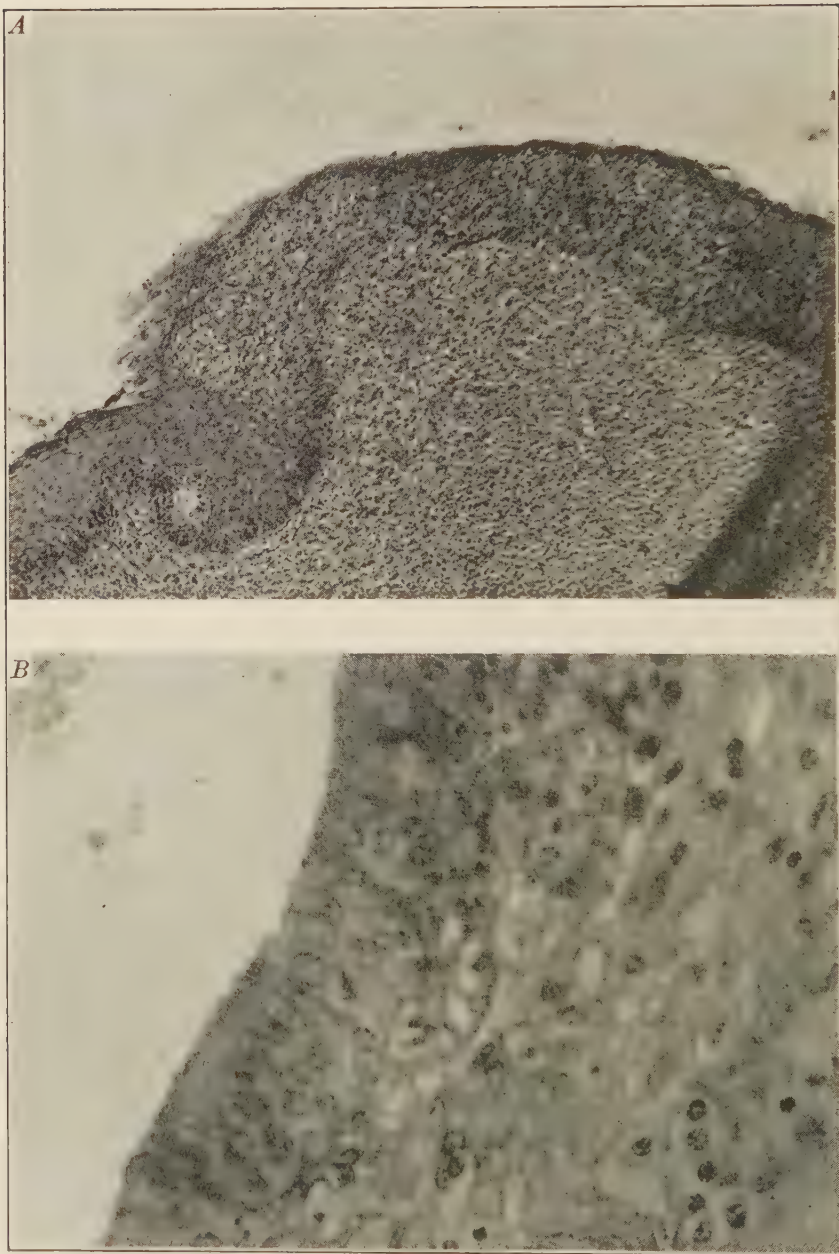


PLATE VIII.—Sections cut at 10 micra, Delafield's hematoxylin and eosin. (A) Vestibule from 9R, seven days after oestrus. Note the very heavy leucocytic infiltration in the epithelium and stroma. $\times 160$. (B) Vagina from 4R, sixteen days after oestrus and three days prior to the next expected heat. Note that there are a few leucocytes in the stroma, that the basement membrane is fairly clear, and that the epithelium is peculiar in that the cells of the surface layer are columnar. The epithelium consists of three cell layers. $\times 670$.

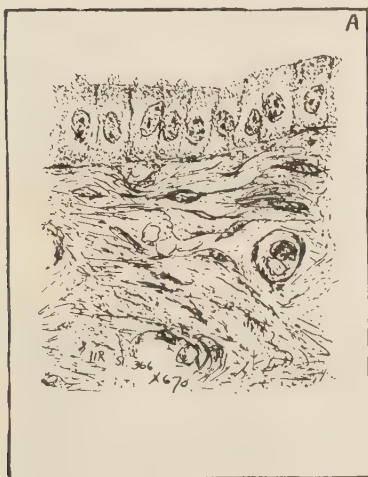


PLATE IX.—Sections of the uterine cornu. Camera lucida drawings. Delafield's hematoxylin and eosin. $\times 572$. (A) From 11R, twelve days after oestrus. Note the cytoplasmic extrusions, the low columnar epithelium, and the absence of leucocytes. (B) From 31Ad, about two days before the next expected heat. Note the pseudostratified epithelium, vacuolar degeneration (v. d.), the polymorphonuclear leucocytes in the stroma and epithelium, and the narrow, dark epithelial cells. (C) From 8R, in heat and just after ovulation. Note the pseudostratified epithelium, vacuolar degeneration, leucocytes in the stroma and epithelium, the narrow clear zone between the basement membrane and the base of the epithelial cells, and the mitotic figure (mit.) (D) From 4P, four days after heat. Note the very tall pseudostratified epithelium, some leucocytes, and the absence of vacuolar degeneration.

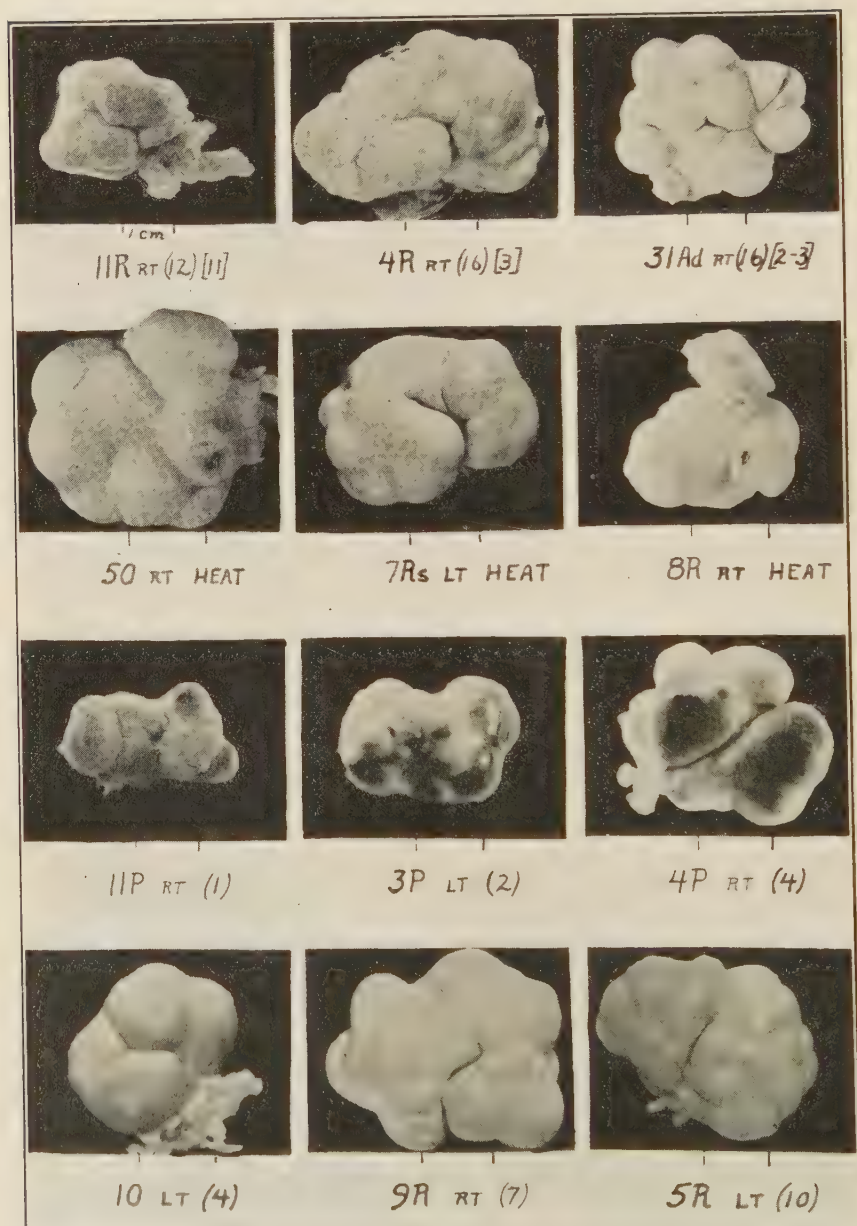


PLATE X.—One ovary from each animal in the series studied is here shown. They are placed in progressive phases of the cycle. Note below each photograph is the scale representing one centimeter. Figures in () denote the number of days since heat and in [] the number of days till the next expected heat.

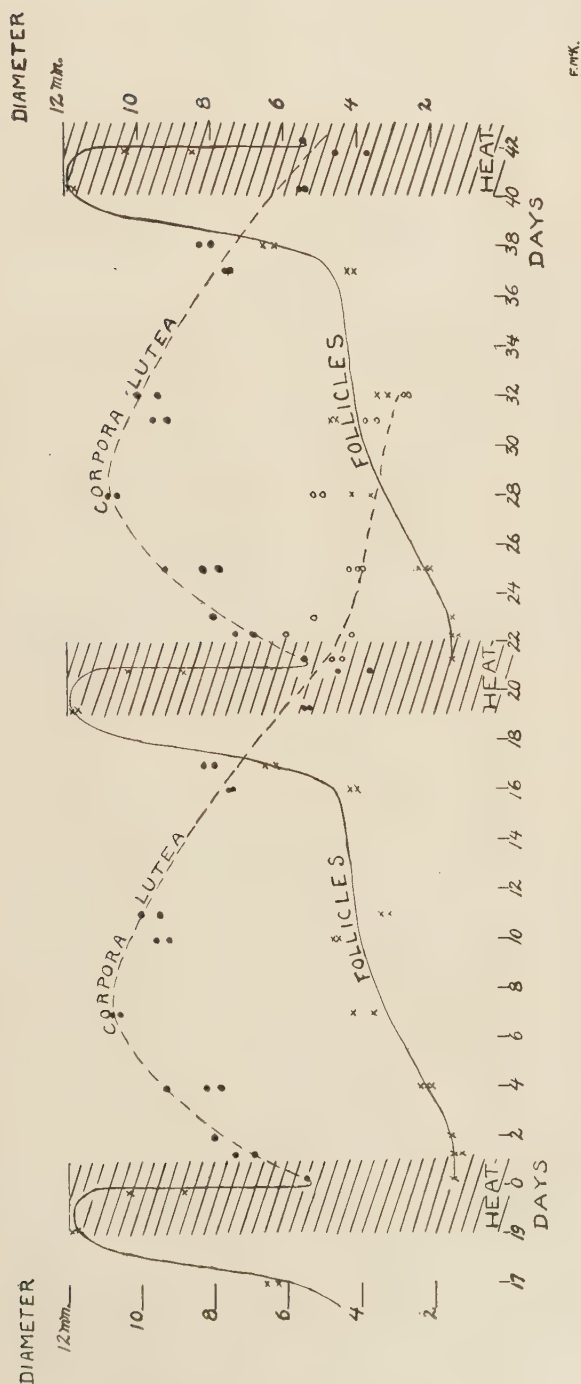


PLATE XI.—A graphical representation of some of the cyclic changes in the ovary. In each ovary, a set of follicles is usually present which is larger than the others in the same ovary; the average size of these follicles of the largest set is graphed. And, too, the size of the corpora lutea is shown, so that one may note in the change in size of the corpora lutea a gradual growth to the seventh day after heat and a retrogression following the twelfth day which lasts some three weeks. Note also that the largest follicles appear at the first signs of heat.

BIOGRAPHY

The author of this dissertation was born May 31, 1900, on Lulu Island, British Columbia, and is the son of William Murdoch and Florence Evelyn (McDonald) McKenzie. He was reared on the farm and attended the public and high schools of British Columbia.

His undergraduate work was taken at the University of British Columbia (B. S. A., 1921). Graduate work was begun August, 1922, at the University of Missouri (A. M. 1923.)

In September, 1923, an appointment as Agent in Animal Husbandry with the United States Department of Agriculture was accepted and graduate study was continued.

